

SPECIFICATION L-100. AIRPORT LIGHTING GENERAL PROVISIONS

DESCRIPTION

100-1.1 These Specifications cover requirements for all Airport lighting installations in Part XI.

GENERAL REQUIREMENTS

100-2.1 The following General Requirements specifications govern all Contract Documents. Perform all Work in strict accordance with these Specifications. Conform with the latest edition of the applicable FAA advisory circulars and revisions for installation details and material and equipment specifications. Provide airport lighting equipment from the FAA approved equipment list in the latest edition of AC 150/5345-53 Appendix 3. The list is also available through the FAA web page, <http://www.faa.gov/>.

Furnish all other basic wiring materials and products as listed by Underwriters Laboratories and as suitable for the purpose specified.

All installation shall be in accordance with National Electrical Contractors Association (NECA) "Standard of Installations".

Contractor's workers shall be trained and experienced in installing, testing and repairing Airport lighting systems. Keep a copy of FAA Advisory Circular (AC) 150/5340-26, and be familiar with its contents. Maintain a copy of the AC on site and follow all pertinent aspects as it relates to the Work. The AC is available through the FAA web page, <http://www.faa.gov/>.

100-2.2 CODES AND REGULATORY REQUIREMENTS. Comply with all ordinances, laws, regulations and codes applicable, in particular, the Wisconsin Administrative Code Chapter ILHR 16 Volumes 1 and 2, and the Life Safety Code. This compliance does not relieve the Contractor from furnishing and installing Work shown or specified which exceeds the requirements of such ordinances, laws, regulations and codes.

NFPA 70 is included by reference in ILHR 16.12. Coincidentally, Chapter ILHR 16 is also inclusive even where NFPA 70 is the only reference mentioned.

Obtain inspections, approvals, and plan and specification reviews required by State Statutes, codes, rules, laws or ordinances. Pay all costs and fees for inspections, approvals, and plan and specification reviews.

Have, as a minimum, one electrician licensed by the State of Wisconsin on the project. If there are local regulations relating to licensing or certification, the more stringent requirements will govern.

100-2.3 ELECTRICAL UTILITY SERVICE POINT. Electrical utility power services required by the Contract Documents shall include all Work from the utility point of service to the service main disconnect switch.

"Construction limits" designations that are indicated on Contract Documents shall not apply to Electric Utility Service work necessary to serve the project and occurring outside of the "construction limits" designations. Pay for the cost for all Work by the Utility company.

Definitions:

Throughout the Specification, two terms are used to describe electrical systems that provide power for lighting and control equipment. The terms used are "Power Source" and "Utility Service". "Power Source" refers to products and materials necessary to connect, distribute, protect, and provide an electrical source for the circuits that feed lighting and control equipment. Under most circumstances, this includes circuit breakers, disconnect switches, boxes, building feeder circuits, branch circuits, raceways, splices, connections, and attachments. Depending on the circumstances, it may include outdoor direct burial feeders, control, and branch circuits. Although each project may vary, typically a Power Source is derived from an existing "Utility Service" and Distribution System, and all work to install a "Power Source" is incidental to some other work.

"Electric Utility Service" refers to products and materials necessary to bring a Public Utility electrical source to the point where it connects to a "Power Source". Under most circumstances, this includes permits, fees, utility poles, transmission circuits, service laterals, utility transformers, or provisions for transformers, service metering equipment, main service disconnect switch, and any costs incurred by the Public Utility on and off the project site, inside and outside the construction limits, in order to bring electrical power to a service point. Although each project may vary, typically a "Utility Service" is a new electrical power system and is paid for independently of all other work.

100-2.4 EXCAVATION. Provide excavation for underground Work in accordance with the construction methods and requirements of Part II Earthwork. Compact backfill for trenches to densities required for adjacent embankment and cut areas.

100-2.5 CONCRETE. Concrete shall be in accordance with Specification P-610.

100-2.6 CUTTING AND PATCHING. Perform all cutting and patching necessary in order to do the Work. Obtain special permission from the Engineer before cutting structural members of finished material. Perform all patching to return the part affected to the condition equal to or exceeding the undisturbed Work.

100-2.7 CLOSING OF OPENINGS.

Firestopping. Close and seal all unused slots, sleeves and other penetrations in fire rated floors, walls or other general construction with an approved firestopping material.

Firestopping material shall be UL listed and tested silicone elastomer specifically formulated for use in horizontal and vertical applications. Material shall possess expansion characteristics and upon exposure to heat above 250°F shall expand to not less than five times its original volume to form a fireproof envelope. Firestopping material shall be UL listed for 3-hour protection, applied in accordance with the manufacturer's recommendation.

Close openings in floor slabs with 16 gauge galvanized steel sheet, securely attached with power-driven studs into the building structure. Firestop with a layer of silicone elastomer not less than 1 inch thick which completely fills the opening. Locate the sheet steel so that the top surface of the silicone elastomer is approximately 1 inch below the finished floor slab.

Close openings in walls with 16 gauge galvanized steel sheet securely attached at the midpoint of the wall thickness and firestopped on both sides of the steel sheet with not less than 1/2-inch thick layer of non-sagging silicone elastomer to fully cover the opening.

Single or multiple pipes passing through walls and floors shall have the annulus space between pipes or between pipes and structure filled with silicone elastomer to provide a 3-hour rated firestop for floors and walls.

Perform patching Work with experienced workers, skilled for the particular type of Work involved. Repair all cut surfaces and match adjacent surfaces. Drill all holes in masonry with rotary drills.

100-2.8 PAINTING AND FINISHING DAMAGE AND TOUCH-UP. Repair all marred or damaged painted finishes with materials and procedures to match original finishes.

100-2.9 ACCEPTANCE OF MATERIALS AND EQUIPMENT. Acceptance of equipment, where applicable, will be based on Section 100-2.10. Be prepared to submit samples of equipment or material for review when requested by the Engineer.

Contractor installed equipment (including FAA approved) shall not generate any electromagnetic interference in the existing and/or new communications, weather, air navigation, and air traffic control equipment. Replace equipment generating interference at no additional cost, with equipment not generating interference and meeting the applicable specifications.

Ascertain that all furnished lighting system components (including FAA approved equipment) are compatible in all respects with each other, and the remainder of new or existing systems. Replace contractor furnished non-compatible components at no additional cost to the Department. Manufactured items furnished shall be the current, cataloged product of the manufacturer. Replacement parts shall be available. There shall be a permanent service organization maintained or trained by the manufacturer to provide repair and replacement services.

Follow the manufacture's installation instructions. Accept full responsibility for their equipment and product selection, cost for materials, effort of installation and the compatibility with airport lighting equipment specified for the project.

Where installation procedures are required to be in accordance with manufacturers' recommendations, have printed copies of the recommendations prior to installation. Do not proceed with installation of the item until recommendations are received. Failure to use recommendations shall be cause for rejection of the equipment or material.

Replace damaged or broken materials or products. Field repair may be authorized in writing by the Engineer instead of replacement on items with long delivery lead times. Repair authorization shall be in written form.

100-2.10 SHOP DRAWINGS. The successful contractor will be required to submit six sets of shop drawings for all electrical equipment. Reference the Specification's article to which each shop drawing is applicable. Include complete catalog information such as product illustrations, ratings, and dimensions as applicable. Submit shop drawings in complete groups of materials (i.e. cables, all lighting fixtures, etc.), and sign each item of material submitted as verification that submittal has been reviewed in detail and is in fact, the Contractor's choice of materials. Bind catalog cuts, plate numbers, descriptive bulletins and drawings (11" x 17" or smaller) in sets with covers showing titles. Verify dimensions of equipment and be satisfied as to code compliance for fit prior to submitting shop drawings for approval. When vendor sheets include more than one product code or catalog data, highlight the data pertinent to the specified material.

Include with each submitted shop drawing the following paragraph:

"It is hereby certified that the (equipment) (material) shown and marked in this submittal is that proposed to be incorporated into the project, it is in compliance with the Contract Documents and Specifications, and can be installed in the allocated spaces. Failure to add the preceding statement or any departure from the enclosed procedure will result in delay of review of submittal. Electrical equipment subject to shop drawing review will be inspected by the Engineer before installation commences. Equipment that cannot be inspected in place, shall be exposed for inspection upon request of the Engineer. Replace non-conforming equipment at the Contractor's expense.

100-2.11 OPERATING AND MAINTENANCE MANUAL. Prepare Operation and Maintenance (O&M) Manuals for all electrical equipment furnished under the Contract. Provide three hard copies and one electronic copy to the Engineer.

The information included must be the exact equipment installed, not the complete "line" of the manufacturer. Where sheets show the equipment other than the equipment actually installed, neatly and clearly identify the installed equipment on the sheets. Give full ordering information assigned by the original parts manufacturer for listed parts. Relabeled and/or renumbered parts information as reassigned by equipment supplier is not acceptable.

Manuals shall contain shop drawings, wiring diagrams, operating and maintenance instructions, replacement parts, lists, and equipment nameplate data for all control equipment and systems installed under the description information designed to acquaint Sponsor's maintenance personnel with equipment operation in each mode of operation. In addition, each manual shall contain a set of the project record drawings reduced to 11" x 17".

Wiring diagrams for each piece of control equipment and system shall be complete drawings for the specific product installed under the contract. "Typical" line diagrams are not acceptable.

Group the information contained in the manuals in an orderly arrangement by specification Table of Contents. Include a typewritten index and divider sheets between categories with identifying tabs in the manuals. Bound the completed manuals with hard board 3-ring binders. Imprint the name of the job, Sponsor, Contractor, and year of completion on the covers. Imprint the name of the job, Sponsor, Contractor, and year of completion on the back edge.

Submit a preliminary copy to the Engineer prior to completion of the project for review. Deliver the three corrected copies to the Sponsor before final payment is approved.

100-2.12 TESTS. Conduct the acceptance test for equipment in the presence of the Engineer, which includes demonstrations, instructions, and tests as outlined in the respective Shop Drawings, equipment and system specifications.

a. Make available at the site the following test equipment:

- (1) Voltmeter/OHM with proper scales.
- (2) Clamp-on ammeter with proper scales.
- (3) Meggar to measure conductor insulation resistance with 100V, 500V and 1000VDC outputs.
- (4) Grounding system resistance tester.
- (5) High voltage probe for measuring up to 5000 VAC.

Test equipment shall remain the property of the Contractor.

b. Have available a licensed electrician with necessary tools and materials to perform the following:

(1) To open and close equipment enclosures, covers to junction boxes, terminal panels and wireways when directed.

(2) To open and reconnect splices other than the cast type when directed.

(3) To make tests and demonstrate system performance.

100-2.13 FACILITY STARTING AND COMMISSIONING. Do not energize illuminated navigational aid equipment included in the Contract Documents for Sponsor use until the Engineer has inspected and the Department has given written authorization for use to the Contractor. Prior to the written authorization, the Contractor may energize the equipment for short periods for testing purpose only and as approved by the Engineer. Do not operate unattended equipment, illuminated navigational or otherwise, until it has been fully prepared, connected, tested, and made ready for normal operation. Correct damage to equipment occasioned by improper or ill-timed operation or testing at the Contractor's expense.

Provide a written statement saying the date and time when the navigational aid equipment will be available for testing and operation. Equipment warranties will be in effect on the date of the written authorization by the Department.

All equipment requiring operation during construction shall require operating instructions for systems and equipment indicated in the Contract Documents. Include in the operating instructions wiring diagrams, control diagrams, and operating and control sequence for each principal system and equipment. Post instructions where directed or attach the operating instructions adjacent to each principal system and equipment including start-up, operating, shutdown, safety precautions and procedures in the event of equipment failure. Provide weather-resistant materials or weatherproof enclosures where appropriate for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal. Prior to project final acceptance and receipt of the O&M Manuals, furnish full instructions for the care, adjustments, and operation and maintenance of all electrical equipment that functions by automation or manual control to the Sponsor's designated representative.

100-2.14 CONTRACT DRAWING. Before roughing-in facilities or installation of equipment, consult all Drawings for obstructions that affect the installation. Verify that field measurements and circuiting arrangements are as shown on Drawings, and that abandoned wiring and equipment serve only abandoned facilities.

The location of the circuits and conductors on the Drawings are diagrammatic, and subject to dimension provided in the details, and as determined by the actual field conditions.

Space requirements and dimensions are nominal and based on typical manufacturer's data, with proper electrical clearances. The Contractor is totally responsible for selecting products that fit the available space, or expanding the given spaces to comply with their bid equipment, plus the necessary NEC code space. The Contractor will not be allowed extra compensation for their bid equipment that does not fit the available space.

100-2.15 CONTRACT DRAWING SYMBOLS AND ABBREVIATIONS. Refer to Symbols and Abbreviations illustrated on Drawings. Other symbols are in common usage, but if uncertainty exists regarding Plan symbols or abbreviation, bring it to the attention of the Engineer for clarification.

100-2.16 CONTRACT DRAWING RECORDS. The Engineer will furnish a newly printed set of Contract Drawings for the Contractor to mark where construction differed from the original Drawings. Keep the set on site at all times and complete this Work and give the Drawings to the Engineer before final payment is approved.

100-2.17 DEMOLITION. Review all the demolition required by the Contract Documents to be removed, relocated, terminated, or extended to accommodate the new construction. As a minimum, the following is required:

a. Remove abandoned wiring to the source of supply.

b. Remove exposed abandoned conduit, including abandoned conduit behind accessible finishes. Cut conduit so that it is recessed with walls and floors, and patch surfaces.

c. Disconnect abandoned electrical outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank covers for abandoned outlets that cannot be removed.

d. Disconnect and remove electrical devices and equipment servicing abandoned outlets that have been removed.

- e. Repair adjacent construction and finishes damaged during demolition work.
- f. Maintain access to existing electrical installations which remain active. Modify installation or provide access to splices as appropriate.
- g. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.

Demolition drawings are schematic and are based on existing record documents. Report discrepancies to the Engineer before disturbing existing installations. Beginning of demolition signifies that the Contractor has investigated existing conditions and accepts the demolition requirement under these specifications.

WIRING METHODS AND MATERIALS

100-3.1 GENERAL. The following Wiring Methods and Materials Specifications govern airside electrical installations that are not otherwise covered by Advisory Circulars or other Parts of the Standard Specifications, and are intended to supplement the Standard Electrical Specifications L-101 through L-125 only.

These Specifications are not intended to govern FAA approved manufactured assemblies tested under ETL, airport landside installations, or Special Provisions, unless they are explicitly mentioned as being included by the Special Provisions.

Definitions:

Airside equipment refers to equipment installed as part of the airfield electrical systems governed or covered by FAA regulations, with restricted access to unauthorized personnel.

Landside equipment is electrical equipment installed as part of public and passenger handling areas, unrestricted.

100-3.2 RACEWAYS. Provide raceways at locations indicated on the Drawings and in accordance with the following specifications. Refer to Specification L-110 for underground electrical duct bank installations.

a. Section Includes.

- (1) Rigid Steel and Intermediate Conduit.
- (2) Rigid Nonmetallic Conduit.
- (3) Electrical Metallic Tubing.
- (4) Flexible Metal Conduit.
- (5) Flexible Polyethylene Duct, Coupling and Connectors.
- (6) Liquid-tight Flexible Metal Conduit.
- (7) Wireway, Auxiliary Gutters.
- (8) Raceway Fittings, Couplings and Connectors.
- (9) Bituminous Fiber Duct.

b. References.

- (1) American National Standards Institute (ANSI). Comply with requirements of the following.

ANSI	C80.2	Rigid and Steel Conduit.
ANSI	C80.3	Electrical Metallic Tubing (EMT), Zinc Coated.
ANSI	870	Wireways, Auxiliary Gutters and Associated Fittings.

(2) National Electrical Manufacturers Association (NEMA). Comply with the requirements of the following.

NEMA TC2 Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).

NEMA TC3 Fittings for PVC Conduit.

NEMA TC7 Flexible Polyethylene Duct.

(3) National Fire Protection Association (NFPA). Comply with requirements of the following.

NFPA 70 National Electric Code.

(4) Underwriters Laboratories, Inc. (UL). Comply with the requirements of the following.

UL 1 Flexible Metal Conduit.

UL 360 Liquid-Tight Flexible.

UL 514B Fittings for Conduit and Outlet Boxes.

UL 886 Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.

UL 1242 Intermediate Metal Conduit. Steel Conduit.

UL 543 Bituminous Fiber Duct.

c. Products.

(1) Rigid Steel Conduit and Intermediate Metal Conduit (IMC).

(a) Use for stub-ups from direct burial and wherever susceptible to severe physical damage.

(b) Use in hazardous (classified) location and Class I, Division 2.

(c) Use for burial in concrete slabs or concrete encasement.

(d) Use for direct contact with earth.

(2) Rigid Nonmetallic Conduit.

(a) Schedule 40—Use for direct burial under driveways and parking lots only. Use under runways, taxiways, and aprons only when encased in concrete.

(b) Schedule 80 – Use for direct burial and stub-ups from direct burial for a distance of two feet maximum. Use as an alternate to Rigid Steel and IMC Conduit, for stub up work only.

(3) Electrical Metallic Tubing (EMT).

(a) Use for branch circuits in dry locations.

(b) Do not bury in ground or in slabs.

(c) Do not use in concrete.

(d) Do not use for circuits operating over 600-volts.

(4) Flexible Metal Conduit.

(a) Use in dry locations.

(b) Do not use in corrosive atmosphere or concealed work exterior locations.

- (c) Use wherever equipment must be isolated for vibration or shifted to its final position.
- (5) Flexible Polyethylene Duct, Couplings, and Connectors.
- (a) Use for conductors and cables below grade installed in trench or by plowing methods as an alternate to underground cable installed in trench with sand base and backfill.
 - (b) Do not use above grade.
- (6) Liquid-Tight Flexible Metal Conduit.
- (a) Use for exterior and damp locations.
 - (b) Sizes 1-1/4-inch and smaller, provide with a continuous copper bonding conductor wound spirally between convolutions.
 - (c) Sizes 1-1/2-inch and larger, provide with an internal grounding conductor and grounding bushings.
- (7) Wireways, Auxiliary Gutters.
- (a) May be used to facilitate installation and future changes in wiring between panel boards, safety switches in close proximity to each other on same or adjacent walls or in same electrical equipment room or area.
 - (b) Provide NEMA 4 stainless enclosure where outdoors or subject to moisture and similar elements.
 - (c) Do not use for constant voltage circuits operating over 100V, unless an equipment grounding conductor is used and bonded to each wireway joint, and bonded to the grounding electrode conductor.
- (8) Raceway Fittings, Couplings and Connectors.
- (a) Use fittings listed and approved for specific conduit or raceway system used. For threaded rigid steel conduit do not use threadless or compression type fittings. For EMT, provide steel or malleable iron "concrete-tight" or "rain-tight" couplings and connectors, compression type or stainless steel multiple locking type. Do not use indentation or set screw type fittings.
 - (b) Bushing and connectors shall be insulated type which maintain continuity of conduit grounding system. Mold or lock insulating material into the metallic body of the fitting. Bushing made entirely of nonmetallic material will not be allowed.
 - (c) Connectors and couplings body shall have wall thickness at least equal to wall thickness of conduit used.
 - (d) Provide flexible metal conduit fittings made of steel or malleable iron and one of the following types:
 - Screw type having an angular wedge fitting between the convolutions of the conduit.
 - Squeeze or clamp type having a bearing surface contoured to wrap around the conduit and clamped by one or more screws.
 - Steel, multiple point type, for threading into internal wall of the conduit convolutions.
 - (e) Liquid-tight flexible metal conduit shall incorporate a steel, nylon or equal plastic compression ring and a gland for tightening. The fitting shall be steel, or malleable iron with insulated throat, with male thread and locknut or male bushing with or without "O" ring seal.

(f) Provide expansion fittings for all rigidly fastened conduits spanning a building expansion joint and if not otherwise mentioned, for all runs exceeding 150 feet in length. Fittings shall be hot-dipped galvanized malleable iron with a packing ring to prevent entrance of water, a pressure ring, a grounding ring and a separate external copper bonding jumper.

(g) Do not use material such as "pot metal" for any type of fitting.

d. Installation.

Complete installation of electrical raceways before starting installation of cables/wires within raceways.

Prevent foreign matter from entering raceways; use temporary closure protection.

During construction, protect stub-ups from damage. Arrange so curved portion of bends is not visible above the finished slab or grade.

Make bends and offsets so the inside diameter is not effectively reduced.

Unless otherwise indicated keep the legs of a bend in the same plane and the straight legs of offset parallel.

Use raceway fittings that are of types compatible with the associated raceway and suitable for the use and location.

Run concealed raceways with a minimum of bends. All bends shall have the longest possible radii.

Install exposed raceways parallel and perpendicular to nearby surfaces or exposed structural members, and follow the surface contours.

Run exposed, parallel or banked raceways together.

Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs where they can be installed parallel.

Where the installation is such that joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system.

Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the protection shoulder.

Where chase nipples are used, align the raceway and coupling square to the box and tighten the chase nipple so no threads are exposed. Running threads are not allowed.

Install pull wires in empty raceway. Use No. 14 AWG zinc-coated steel or plastic having not less than 200 pounds tensile strength unless indicated otherwise in the Contract Documents. Leave not less than 12 inches of slack at each end of the pull wire.

In slabs and walls, locate raceways in middle third and leave at least 2 inches concrete cover. Lateral spacing of raceways shall be not less than three diameters of the raceway.

Tie raceway to reinforcing rods or support to prevent sagging or disturbing when concrete is placed.

At expansion joints, provide expansion fittings and cross at right angles to joint.

Provide conduits stubbed up through or from concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside.

Provide flexible conduits only for connections to electrical equipment when it is subject to movement, vibration, misalignment, or where noise transmission is to be eliminated or reduced. Install all bonding and grounding conductors for liquid-tight, flexible metallic conduit runs within the conduit. Allow all PVC conduits directly buried to acclimate to the installed temperature before installation commences (one hour minimum). Flexible conduit shall be of the liquid-tight type when installed under any of the following conditions:

- (1) Exterior locations (ultra violet light rated)

- (2) Moisture or humidity laden atmospheres where it is possible for condensation to accumulate. Corrosive atmospheres.
- (3) Wherever there is a possibility of seepage or dripping of oil, grease, or water.
- (4) Raceway Sealing Fittings shall be zinc coated, cast or malleable iron type. Use continuous drain type fittings that are used to prevent passage of water vapor..
 - (a) Upon completion of installation of raceways, inspect interiors of raceways at all outlet, junction and pull boxes, and remove burrs and obstructions.
 - (b) Run a swab or mandrel to remove dirt and blockages. Replace new raceways that are deformed and prevent the passage of a mandrel. Replace used raceways that are deformed and prevent the passage of a mandrel at the Engineer's discretion with payment in accordance with Extra Work Section 40-04.
 - (c) Remove dirt and construction debris from outlet, junction and pull boxes.

100-3.3 FEEDER AND BRANCH CIRCUIT WIRE AND CABLE.

Provide feeder and branch circuit wire and cable at locations indicated on the Drawings and in accordance with the following Specifications. Refer to Specification L-108 for underground cable installations.

a. Section Includes.

- (1) Copper conductors.
- (2) Tap type connectors.
- (3) Split-bolt connectors.
- (4) Wire nut connectors.

b. References.

- (1) American Society for Testing and Materials (ASTM). Comply with requirements of the following:

ASTM	B 1	Standard Specification for Hard Drawn Copper Wire
ASTM	B 2	Standard Specification for Medium-Hard-Drawn Copper Wire
ASTM	B 3	Standard Specification for Soft or Annealed Copper Wire
ASTM	B 8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, medium-Hard, or Soft
ASTM	D 753	Standard Specification for General Purpose Polychloroprene Jacket for Wire and Cable.

- (2) Institute of Electrical and Electronics Engineers (IEEE). Comply with the following standards which apply to wiring systems:

IEEE	82	Test Procedure for Impulse Voltage Tests on Insulated Conductors
IEEE	241	Recommended Practice for Electric Power Systems in Commercial Buildings.

- (3) National Fire Protection Association (NFPA). Comply with NFPA 70 requirements for construction, installation and color coding of electrical wire, cable and connections.

- (4) National Electrical Manufacturers Association (NEMA). Comply with requirements of the following:

NEMA	WC 3S-19-81	Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
NEMA	WC 5S-61-402	Thermoplastic-Insulated Wire and Cable for the transmission and Distribution of electrical Energy

NEMA	WC 7/S-66-524	Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the transmission and Distribution of Electrical Energy.
NEMA	WC 8/S-68-516	Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

(5) Underwriters Laboratory (UL). Provide Material conforming to the following standards

UL	44	Rubber-insulated Wires and Cables
UL	83	Thermoplastic-Insulated Wires and Cables
UL	486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors
UL	854	Service-Entrance Cables

c. Products

(1) Conductors.

For all constant voltage circuits 600 volts or less, provide wire rated 600 V minimum of the single conductor annealed copper type.

Conductors No. 10 AWG and smaller may be solid, and No. 8 AWG and larger shall be stranded.

Conductivity shall not be less than 98 percent at 20°C (68°F) or resistivity greater than 1.7 microhms per centimeter.

For dry and wet locations provide Type THHN/THWN, 75° maximum.

(2) Cable.

For all constant voltage circuits 600 volts or less, provide UL listed cables of sizes, ampacity, temperature ratings and insulating materials as indicated on the drawings. Where no sizes, ampacity, temperature or insulating materials are indicated, use NFPA 70.

(3) Connectors and Splices.

Provide UL listed metal connectors of sizes ampacity temperature ratings, materials, and classes required by NFPA 70 and NEMA standards for applications and services indicated.

For Branch Circuit wires No. 10 AWG and smaller, provide solderless, insulated pressure cable type connectors, 600 V, of the compression or indent type or wire nut connectors. Temperature rating of connectors shall be at least equal to that of the wire on which they are used.

For Branch Circuit wires No. 8 AWG and larger wire, provide socket head cap, hex screw or bolt clamp type connectors, manufactured of high conductivity copper alloy or bronze castings. Select proper connector for each wire size. Retain cable sizes 250 MCM and larger in the connector by twin clamping elements.

(4) Insulating Materials.

Provide plastic electrical insulating tape which is flame retardant, cold and weather resistant. Tape for use in areas subjected to temperatures 40°C, or where the tape will be subjected to an oil splash, use a tape with a minimum thickness of 8.5 mils that consists of an oil-resistant vinyl backing with an oil-resistant acrylic adhesive.

Provide all insulating materials for splices and connections such as glass and synthetic tapes, putties, resins, splice cases, or compositions of the type approved for the particular use, location, voltage and temperature, and apply and install in an approved manner, all in accordance with the manufacturer's recommendations.

(5) Prohibited Products.

The use of non-metallic sheathed cable Types NM to NMC, armored-bushed cable (BX) and armor-clad cable (AC) and service entrance cables (SE and USE) is prohibited.

d. Installation – General.

Deliver wire and cable packaged in factory-sealed containers.

Store wire and cable in a clean dry space in original containers. Protect products from weather, damaging fumes, construction debris and traffic.

Handle wire and cable carefully to avoid abrading, puncturing and tearing wire and cable insulation and sheathing. Ensure that the dielectric resistance integrity of wires and cables is maintained.

Unless otherwise indicated in Contract Documents, install all wiring in conduit, in conformance with NFPA 70.

Provide wire, cables and connectors necessary for a complete installation from point of service connection to all receptacles, lighting fixtures, devices, utilization equipment and outlets.

Do not use wire and cable manufactured more than 12 months prior to date of delivery to the site.

Neatly and securely bundle and tie all individual circuits located in branch circuit panelboards, signal cabinets, signal control boards, switchboards and motor control centers, switchboards, motor control centers and pull boxes. Bundle and tie with either marlin twine 2- or 3-ply lacing or nylon straps made of self-extinguishing nylon having a temperature range of -65°F to +350°F. Each strap shall be constructed with a locking hub of head on one end and a taper on the other.

Securely fasten nonferrous identifying tags or pressure sensitive labels to all cables, feeders, and power circuits in vaults, pull boxes, manholes, and at termination of cables. Stamp or print tags or labels to correspond with markings on drawings or marked so that feeder or cable may be readily identified. If suspended type tags are provided, attach them by approximately 55-pound test monofilament line or slip free plastic cable lacing units.

e. Installation – In Conduit.

Refer to L-100-3.2, RACEWAYS, for the preparation of raceways for wire and cables.

Provide suitable installation equipment to prevent cutting and abrasion of conduits during the pulling of wires and cables, according to the following:

- (1) Use ropes for pulling of conductors in raceways with existing circuits made of polyethylene or other suitable nonmetallic material.
- (2) Pull conductors simultaneously where more than one is being installed in same raceway.
- (3) Use pulling compound or lubricant where necessary; compound shall not deteriorate conductor or insulation.
- (4) Use lubricants conforming to UL requirement as applicable.
- (5) Attach pulling lines to conductor cables by means of either woven basket grips or pulling eyes attached directly to the conductors. Do not use rope hitches.
- (6) Where polyethylene insulation is used, a pulling lubricant is required. Use lubricant non-injurious to the insulation.

Install cable supports for all vertical feeders in accordance with the applicable sections of the NFPA 70. Provide cable supports of the wedge type which firmly clamp each individual cable and tighten due to the cable weight.

Install exposed cable parallel and perpendicular to surfaces or exposed structural members and follow surfaces contours, where applicable.

f. Installation – Above Grade.

- (1) In making a splice, bring connectors up securely upon the conductors so that all conductors are equally engaged, the insulation is not ruptured, no bare wires are exposed or have "backed off" due to the application of pressure, and the connection will not loosen due to cycling or vibration, in order the insure an efficient splice.
- (2) Follow the number, size, and combinations of conductors permitted as listed on manufacturer's packaging.
- (3) Fully insulate connectors by a skirt, or taped to provide an insulation value at least equal to the rating of wires being connected.

Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values or comply with tightening torques specified in UL 486A and 468B.

Color code all secondary service, feeder and branch circuit conductors throughout the project secondary electrical system as follows:

<i>Phase</i>	<i>208Y/120 Volts</i>	<i>240/120</i>	<i>480Y/277 Volts</i>
A	Black	Black	Yellow
B	Red	Red	Brown
C	Blue	—	Orange
Neutral	White	White	Gray
Ground	Green	Green	Green

The colors shall be factory–applied entire length of the conductors by one of the following methods except as noted and limited in the following:

- (1) Solid color compound
- (2) Solid color coating
- (3) Surface printing every 12 inches, maximum spacing of 18 inches.
- (4) All grounding and phase conductors No. 10 AWG and smaller shall be solid color compound or solid color coating.
- (5) All grounding and phase conductors No. 8 AWG and larger color coded with pressure sensitive tape shall have a background color or shall have field applied color coding methods per UL and NFPA 70.
- (6) Apply color pressure–sensitive plastic tape in half overlapping turns for a distance of 6 inches or all terminal points and in all boxes in which splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding.
- (7) Use 3/4–inch wide tape in colors as specified.
- (8) Do not be obliterated cable identification markings by taping. Tape locations may be adjusted slightly to prevent obliteration of cable markings.

Seal cables and conductors entering from underground between cable and raceway or sleeve, with a waterproof non–hardening sealing compound.

g. Installation – Manholes.

Install and support cables in manholes on steel racks with porcelain or equal insulators. Train cable around manhole walls but do not bend cable to a radius less than the limits in NFPA 70.

Cover constant voltage power cables located in manholes and handholes with arcproof and flameproof tape. Apply the tape in a single layer, one-half lapped, or as recommended by the manufacturer.

h. Installation – Below Grade.

Refer to Specification L-108 for underground cable installations.

Conduct tests with a meggar on constant voltage circuits will be performed so as not to harm the conductor insulation. Follow manufacturer's instructions and Subsection 100-2.12.

100-3.4 CONTROL AND SIGNAL WIRE AND CABLE. Provide control wire, signal wire, and cable at locations indicated on the Drawings and in accordance with the following specifications. Refer to Specification L-108 for underground cable installations.

a. Section Includes.

- (1) Class 2 and Class 3

b. Reference Standards.

- (1) American Society for Testing and Materials (ASTM). Comply with requirements of the following:

ASTM	B 3	Standard Specification for Soft or Annealed Copper Wire.
ASTM	B 8	Standard Specification for Concentric-Lay-Stranded Copper conductors, Hard, Medium-Hard, or Soft.

- (2) Institute of Electrical and Electronics Engineers (IEEE): Comply with the following IEEE Standards:

IEEE	82	Test Procedure for Impulse Voltage Tests on Insulated Conductors.
IEEE	241	Recommended Practice for Electric Power Systems in Commercial Buildings.
Vol. IGA-3		Reducing Electrical Noise in Instruments Circuits.

- (3) National Electrical Manufacturers Association (NEMA)/Insulated Cable Engineers Association, Inc. (ICEA): Comply with applicable requirements of the following:

NEMA	WC 3/S-19-81	Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
NEMA	WC 5/S-61-402	Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
NEMA	WC 7/S-66-524	Cross-linked-thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
NEMA	WC 8/S-68-516	Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical energy

- (4) National Fire Protection Association (NFPA): Comply with NFPA 70 requirements for construction, installation and color coding of control and signal wire Class 1, Class 2, and Class 3.

- (5) Underwriters Laboratories, Inc. (UL): Provide material conforming to the following UL Standards:

UL	44	Rubber-Insulated Wires and Cables.
UL	83	Thermoplastic-insulated Wires and Cables.
UL Labeled:		Provide control and signal wire UL listed and labeled.

c. Products.

Provide control and signal wires and cables single conductor and multiple conductors, shielded and unshielded, as indicated in the Contract Documents.

Wires and cables shall have 75°C rating minimum, designed to provide a clean signal in a high noise level environment, and suitable to reject static magnetic, common mode and cross talk noise.

Use control and signal wire that is coated copper solid or stranded Class B.

Stranded conductors shall be constructed of short lay seven strand minimum concentric bare copper wires.

Use the size of conductors that is suitable for the current required for satisfactory operation of the apparatus controlled and with proper consideration of circuit's length, unless indicated otherwise in the Contract Documents.

Provide conductors with a primary insulation material that is heat, moisture, flame, and chemical, resistant crosslinked polyethylene, or PVC high temperature insulation material.

Cable shall have nonhygroscopic fillers and a high temperature nonhygroscopic tape shall be applied over the cable code.

Multi-conductor cable shall have conductors color coded.

Control cable for above grade dry locations shall have an outer covering, fabricated of thermoplastic with flame, heat and moisture resisting compounds.

d. Installation.

Deliver wire and cable packaged in factory-sealed containers, or wound on NEMA wire and cable reels. Cable ends shall be sealed with shrinkable self-sealing end caps or by other proper means that protects wires and cables against moisture and dust. Ensure that dielectric resistance integrity of wires and cables is maintained.

Store wire and cable in a clean dry space in original containers. Protect products from weather, damaging fumes, construction debris and traffic.

Handle wire and cable carefully to avoid abrading, puncturing and tearing wire and cable insulation and sheathing. Ensure that the dielectric integrity of wires and cables is maintained.

Wire and cables shall be rated for 600 volts minimum. Where the operating voltage is less than 100 volts, the wire and cables may be insulated for 300 volts.

Do not use wire and cable manufactured more than 12 months prior to date of delivery to the site.

Neatly and securely bundle all conductors in signal cabinets and signal control panels. Bundle and cable with nylon straps made of self-extinguishing nylon having a temperature range of -65°F to +350°F.

Provide pressure sensitive labels, securely fastened to each conductor at each termination of single conductor or multiconductor cables. Stamp or print Tags or labels to correspond with markings on the Contract Documents. Mark conductors so they can be readily identified.

Splices in control wire are not permitted. All control wire shall be continuous from terminal block to terminal block.

Prevent pickup of magnetic and static noise by routing cables and wires away from noise sources such as power cables, generators, motors, and any arc producing equipment. Control wiring subject to noise shall be twisted and provided with a total coverage grounded shield.

Prevent cables and wires from picking up common mode noise by grounding the shield at one point. Locate the ground point at the point where the instrument circuit is grounded and isolated from all other grounds.

Prevent pickup of cross talk noise on multiple pair cable by using cables with individually shielded, isolated pair shields.

100-3.5 ELECTRICAL BOXES AND FITTINGS. Provide electrical box and fittings as shown on the drawings and in accordance with the following specifications.

a. Section Includes.

- (1) Outlet boxes
- (2) Junction boxes
- (3) Pull boxes
- (4) Conduit bodies
- (5) Bushings
- (6) Locknuts
- (7) Knockout closures

b. References.

(1) National Electrical Manufacturers Association (NEMA): Comply with applicable requirements of the following.

NEMA	OS 1	Sheet Steel Outlet Boxes, Device Boxes, Covers and Box Supports
NEMA	FB 1	Fittings, Cast Metal Boxes

(2) National Fire Protection Association (NFPA): Comply with NFPA 70, for construction and installation of electrical wiring boxes and fittings.

(3) Underwriters Laboratories Inc. (UL): Comply with applicable requirements of the following.

UL 50	Cabinets and Boxes
UL 514A	Metallic Outlet Boxes
UL 514B	Fittings for Conduit and Outlet Boxes, Flush-Device Boxes and Covers
UL 886	Outlet Boxes and Fittings for Hazardous (Classified) Location.

c. Products

Provide galvanized or other approved corrosion resistant finish for all boxes, accessories and fittings.

Provide minimum 4-inch square by 1-1/2-inch deep, one piece, deep-drawn, galvanized steel outlet boxes for general use. Provide 4-inch octagonal concrete boxes and hung ceiling boxes of the folded or welded type where required by project conditions. Construct with stamped knockouts in the back and sides. Provide threaded screw holes with corrosion-resistant screws for securing box covers and wiring devices.

Provide interior outlet box accessories as required for each installation, including covers, mounting brackets, hangers, extension rings, cable clamps, and metal straps for supporting outlet boxes, which are compatible with outlet boxes being used and fulfilling requirements of individual wiring situations.

Provide corrosion-resistant cast-metal weatherproof outlet boxes, of types, shapes and sizes, with threaded conduit ends, cast-metal face plates with spring-hinged waterproof caps suitable configured for each application, including face plate gaskets and corrosion-resistant fasteners.

For Junction and Pull Boxes, provide galvanized sheet steel junction and pull boxes, with screw-on covers and of types, shapes and sizes, to suit each respective location and installation. Provide welded seams and stainless steel nuts, bolts, screws, and washers. Where necessary for boxes to provide a rigid assembly, provide integral structural steel bracing.

Provide galvanized cast-metal conduit bodies, of types, shapes, and sizes, to suit respective locations and installation, construct with threaded-conduit-entrance ends, removable covers, and corrosion-resistant screws.

Provide corrosion-resistant punched-steel box knockout closures, conduit locknuts, malleable iron conduit bushings and offset connectors of types and sizes to suit respective uses and installation.

Provide boxes UL listed for the particular type and class for Hazardous Locations.

Provide outlet boxes conforming to UL 886 for hazardous locations and install in conformance with NFPA 70 Articles 500 through 555 for Hazardous Locations.

d. Installation.

Coordinate installation of electrical boxes and fittings with wire/cable and raceway installation work.

Provide weatherproof outlets for all interior and exterior locations exposed to weather or moisture.

Provide knockout closures to cap unused knockout holes where blanks have been removed.

Provide boxes of sizes adequate to meet NFPA 70 volume requirements, but in no case smaller than sizes indicated in the Contract Documents.

When the mounting height of a wall-mounted outlet box is shown on the drawings, it is defined as the height from the finished floor to a finished grade, to the horizontal center line of the cover plate. Where mounting heights are not indicated or where heights and locations interfere with mechanical, architectural or structural features, install outlet boxes as approved by the Engineer.

Mount outlet boxes for switches with the long axis vertical. Mount boxes for receptacles either vertically or horizontally but consistently one way. Mount three or more gang boxes with the long axis horizontal. Do not use sectional (gangable) boxes, device plates as covers for boxes in exposed locations, or round boxes where conduit must enter box through side of box.

Protect outlet boxes to prevent entrance of debris. Thoroughly clean foreign material from boxes before conductors are installed.

At the following locations use threaded hub type boxes with gasketed weatherproof covers:

- (1) Exterior locations.
- (2) Where exposed to moisture laden atmosphere
- (3) Where indicated in the Contract Documents.

For installation of junction and pull boxes, conform to the following:

- (1) For boxes exposed to rain or installed in wet locations use NEMA 4 stainless steel.
- (2) Conductors larger than 3/0 in any pull or junction box including equipment grounding conductors shall not exceed the sizes in Table 1.

TABLE 1. CONDUCTORS

<i>SIZE OF LARGEST CONDUCTORS</i>	<i>MAXIMUM NUMBER OF CONDUCTORS</i>
No. 4/0 AWG	30
250 MCM	20
500 MCM	15
Over 500 MCM	10

Provide each box with sufficient clamps, grids, or devices to which cables are secured in neat and orderly fashion permitting ready identification and so that no cable will have an unsupported length of more than 30 inches.

100-3.6 WIRING DEVICES. Provide wiring devices at locations indicated on the Drawings and in accordance with the following Specifications.

a. Section Includes.

- (1) Receptacles.
- (2) Ground-fault circuit interrupters.
- (3) Switches.
- (4) Photocells.

b. References.

(1) American National Standards Institute (ANSI): Provide plugs and receptacle devices constructed in accordance with ANSI C73, "Attachment Plugs and Receptacles."

(2) Institute of Electrical and Electronics Engineers (IEEE): Construct and install wiring devices in accordance with requirements of IEEE 241, "Recommended Practice for Electric Power Systems in Commercial Buildings."

(3) National Electrical Manufacturers Association (NEMA): Provide wiring devices constructed and configured in accordance with the requirements of:

NEMA	WD 1	General Requirements for Wiring Devices.
NEMA	WD 2	Semiconductor Dimmers for Incandescent Lamps.
NEMA	WD 6	Wiring Devices – Dimensional Requirements

(4) National Fire Protection Association (NFPA): Comply with NFPA 70, as applicable to construction and installation of electrical wiring devices.

(5) Underwriters Laboratories, Inc. (UL): Provide wiring devices which are UL listed and comply with the requirements of:

UL	5	Surface Metal Raceways and Fittings
UL	20	General-Use Snap Switches
UL	498	Attachment Plugs and Receptacles.
UL	514A	Metallic Outlet Boxes
UL	514B	Fittings for Conduit and Outlet Boxes.
UL	943	Ground-Fault Circuit Interrupters.

c. Products.

Provide factory-fabricated wiring devices, in types, colors, and electrical ratings for applications indicated in the Contract Documents. Provide devices and wall plates. Submit color selections for approval by Engineer.

Provide specification grade single and duplex receptacles, 2-pole, 3-wire grounding, with green hexagonal equipment ground screw, ground terminals and poles internally connected to mounting yoke, 20 A, 125 V, with metal plaster ears, design for side wiring with four captively held binding screws and provisions for back wiring with NEMA configuration 5-20R unless otherwise indicated in the Contract Documents.

Provide feed-through type ground fault circuit interrupters, with duplex receptacles, capable of protecting connected downstream receptacles on single circuit, and installed in a 2-3/4 inch deep outlet box without adapter. Provide grounding type UL rated Class A, Group 1. rated 20 A, 125 V, 60 Hz, solid-state ground fault sensing and signaling with 5 milliamperes ground fault trip level, equip with NEMA configuration 5-20R.

Provide weatherproof single and duplex receptacles, 20A, 125 V, NEMA 5–20R in cast metal box with gasketed, weatherproof cast metal cover plate and gasketed cap over each receptacle opening. Provide cap with spring hinged cover flap.

Provide specification grade, general duty flush single pole 3–way and 4–way toggle and key operated AC quiet snap switches, 20 A, 120–277 V, with mounting yoke insulated from mechanism, equip with plaster ears, switch handle and back or side–wired screw terminals. Provide captive or terminal type terminal screws not smaller than No. 8. Provide back–wired devices with separate access holes for wiring. The Engineer will select the color.

Provide switches for hazardous locations that meet all requirements of NFPA 70 for Class 1, division 1. Provide covers with a finish to match the housing for surface mounted units.

Provide wall plates for each switch, receptacle, signal special purpose outlet. Do not use sectional gang plates. Provide multi–gang outlet plates for multi–gang boxes. Use wall plates in accordance with UL 514A, UL 514B, and UL 514C.

Provide 0.04 inch satin finished steel in all unfinished areas and mechanical spaces. Match the finish of fastening crews with the plates. Provide plates for exposed screw jointed fittings that match the fittings with edges of plates flush with edges of fittings and made of heavy cadmium plated steel. Provide plates for finished areas subject to wet or rain as directed by the Engineer.

For FAA approved lighting and NAVAIDS, provide FAA required photocells with (2) N.O. 20 amp contacts, surge protection, energizing at 35 foot candles and de-energizing at 60 foot candles, in cast aluminum enclosure. For all other lighting provide quick–response, cadmium–sulfide type photocell with 15 to 20 second built–in time delay to prevent response to momentary lightning flashes, car headlights or cloud movements. Photocell will energize when north sky light decreases to 1.5 foot candles and will remain energized until north sky light increases from 3 to 5 footcandles. Provide photocells of voltage and wattage ratings as indicated in the Contract Documents.

d. Installation.

Handle wiring devices carefully to prevent damage. Do not install damaged wiring devices.

Store wiring devices in a clean and dry place. Protect from dirt, construction debris, and physical damage.

Install wiring devices as indicated, in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to fulfill project requirements. Where not indicated, mount switch adjacent to latch jamb of door.

Coordinate with other Work, including painting, electrical boxes and wiring Work, as necessary to integrate installation of wiring devices with other Work.

Install wiring devices only in electrical boxes which are clean; free from building materials, dirt, and debris.

Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A, "Wire connectors and Soldering Lugs for Use with Copper Conductors."

Install switches with centerline located 4 feet above finished floor unless otherwise indicated. Install receptacles in machine with centerline 4 feet above finished floor. Locate all other devices as indicated in the Contract Documents or as direct by the Engineer.

Test wiring devices for electrical continuity, and for short–circuits prior to energizing circuitry. Ensure proper polarity of connections is maintained.

100–3.7 CABINETS AND ENCLOSURES. Provide covers, cabinets, and individual hinged–door enclosures for all electrical systems as indicated on the Drawings and in accordance with the following Specifications.

a. References.

(1) National Electric Manufacturers Association (NEMA). Comply with NEMA 250, "Enclosures for Electrical equipment 1000 Volts Maximum."

(2) National Fire Protection Association (NFPA). Comply with NFPA 70, "National Electrical Code" for application, and installation of electrical cabinets and enclosures.

(3) Underwriters Laboratories, Inc. (UL). Provide electrical cabinets and enclosures which are UL listed and labeled, and constructed in conformance with UL 50 "Cabinets and Boxes."

b. Products.

Provide cabinets and enclosures as follows:

(1) Surface NEMA 1 Cabinets and Enclosures:

(a) Provide a front consisting of a one-piece sheet steel frame and a hinged door with catch and lock.

(b) Provide each cabinet with a combination catch and flat key lock.

(c) Hinge doors directly to cabinet, with 3/4-inch flange around all edges shaped to cover edge of box.

(2) Surface NEMA 12 Cabinets and Enclosures:

(a) Fabricate of minimum 16 MSG steel with continuous welded seams.

(b) Provide removable doors, with neoprene door gasket attached with oil-resistant adhesive, and held in place with steel retaining strips. Provide removable internal mounting panel for component installation.

(c) Provide multiple doors where required. Individual door width shall be no greater than 24 inches.

(d) Provide butt hinges or continuous hinges.

(e) Furnish single door cabinets with padlock and hasp, and double door cabinets with 3-point handle-operated-latch plus hasp.

(3) Surface NEMA 4 Cabinets and Enclosures:

(a) Provide features similar to those for NEMA 12 units except provide NEMA 4 protection against hose directed water. Provide multiple cover clamps instead of handle latches. Provide doors over 36 inches in height with vault handle and a 3-point catch, arrange to fasten door at top, bottom, and center.

Paint all cabinets and enclosures located in dry locations, unless noted otherwise in the Contract Documents.

In addition to a priming coat, give all outside surfaces of trim and doors a factory finish coat of gray paint. All cabinet interiors and panel mounted back plates shall be white.

NEMA 4 stainless cabinets and enclosures shall maintain a natural finish.

Provide cabinets and enclosures with provision for cabinet grounding without penetrating exterior wall of the enclosure.

c. Installation.

Touch up all scrapes and other mars in the enclosure finish equal to the manufacturer's finish.

Mount cabinets at a uniform height, nominally 6 feet 6 inches to the top of the enclosure above finished floor, except as otherwise noted in the Contract Documents.

Support and fasten all cabinets securely in place.

100-3.8 SUPPORTING DEVICES. Provide all electrical supports, anchors, sleeves, seals, fastenings and other components indicated on the drawings and in accordance with the following specifications.

a. Section Includes.

- (1) Clevis hangers.
- (2) Riser clamps.
- (3) C-clamps.
- (4) One-hole conduit straps.
- (5) Two-hole conduit straps.
- (6) Round steel rods.
- (7) Expansion anchors.

b. References.

- (1) National Fire Protection Association (NFPA). Comply with NFPA 70 as applicable to construction and installation of electrical supporting devices.
- (2) Underwriters Laboratories, Inc (UL). Conform to UL listings and labeling.

c. Products.

Provide supporting devices with manufacturer's standard materials, designed and constructed in accordance with published product information.

Provide all supports, support hardware and fasteners hot dipped galvanized for exterior installations and cadmium plated for interior installations.

Provide manufactured standard supports including clevis hangers, risers clamps, conduit straps, threaded C-clamps with retainers, wall brackets and spring steel clamps.

Provide U-channel strut system for mounting and supporting electrical equipment. Fabricate strut from 16-gauge hot-dip galvanized steel sheet, 9/16-inch diameter holes, 8-inches on center on top surface. Use fittings that are compatible with the U-channel struts.

d. Installation.

Install hangers, sleeves, seals, U-channel supports and fasteners as indicated and in accordance with manufacturer's written instructions. Comply with requirements of NFPA 70 and American National Standards Institute (ANSI)/National Electrical Manufacturers Association (NEMA) for installation of supporting devices.

Coordinate with other electrical work, including raceway and wiring work.

Provide raceway structural support capacity equal to the maximum weight of the raceway plus a safety factor of 200 pounds. Provide additional support strength where required to prevent distortion of raceway during wire pulling.

Provide individual and multiple (trapeze) raceway hangers, and riser clamps to support raceways. Provide U-bolts, clamps, attachments, and other hardware for hanger assembly, and for securing hanger rods and conduits.

Arrange for grouping of parallel runs of horizontal raceways to be supported together on trapeze type hangers where possible.

Support individual horizontal conduits and EMT 1-1/2 inch size and smaller by either one or two hole pipe straps or separate pipe hangers. Use separate pipe hangers for larger sizes. Spring steel fasteners may be used instead of pipe straps or hangers for sizes 1-1/2-inch and smaller in dry locations. For hanger rods with spring steel fasteners, use a minimum 1/4-inch diameter or larger threaded steel to meet the safety factor. Use steel

fasteners that are specifically designed for supporting single conduits or EMT. Do not use wire as a means of support.

Space supports for metallic raceways in accordance with the requirements of this Section and the requirements of the NFPA 70, except as otherwise indicated.

In vertical runs provide such support that the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports, with no weight load on raceway termination or conductor terminals.

Provide supports for all miscellaneous electrical components as required to produce the same safety allowances as specified for raceway supports previously mentioned. Provide metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes and junction boxes.

Install cable supports in strict compliance with manufacturer's instructions. Spacing should not exceed NFPA 70 tabulation for spacing of conductor supports. Allow adequate slack in conductors to prevent any stress on terminations. Consider conductor thermal expansion and contraction in installation.

Securely fasten all electrical items and their supporting hardware including, but not limited to, conduits, raceways, cables, busways, cabinets, boxes, switches, and control components to a building structure, or structural fixture, unless otherwise indicated.

Fasten by means of round head full threaded hood screws on wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; by machine screws; welded threaded studs, or spring-tension clamps on steel work. Threaded studs driven in by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts. Do not weld conduits or pipe strap inserts or steel structures. In partitions of light steel construction use sheet metal screws.

Holes cut to a depth of more than 1/2 inches in reinforced concrete or to a depth of more than 3/4-inch in concrete joints shall not cut the main reinforcing bars. Fill holes that are not used.

On loads applied to any fastener do not exceed one-fifth of the proof test load. Use vibration and shock-resistant fasteners, where applicable.

Rawl plugs are not permitted.

100-3.9 ELECTRICAL IDENTIFICATION. Provide electrical identification as indicated on the drawings and in accordance with the following Specifications.

a. Section Includes.

- (1) Buried electrical line warnings.
- (2) Identification of electrical power, control and communication, cables and conductors.
- (3) Operational instruction signs.
- (4) Warning and caution signs.
- (5) Equipment labels and signs.

b. References.

- (1) American National Standards Institute (ANSI). Comply with requirements of ANSI A13.1, "Scheme for the Identification of Piping Systems" with regard to type and size of lettering for raceway and cable labels.
- (2) National Fire Protection Association (NFPA). Comply with NFPA 70, "National Electrical Code" requirements for identification and for provision of warning and caution signs for wiring and equipment.

c. Products.

Provide manufacturer's standard products of categories and types required for each application, except as otherwise indicated.

Use pre-printed, flexible, self-adhesive marking labels for raceways with a legend indicating voltage and service. Size: 1-1/8 inches high by 4 inches long for raceway 1-inch diameter and less, 1-1/8 inches high by 8 inches long for raceway over 1-inch diameter. Color: Black legend on orange background.

Use permanent bright-colored continuous-printed plastic Underground Line Marking Tape compounded for all direct-burial signal and communication circuits; not less than 6 inches wide by 4 mils thick. Provide printed legend indicative of general type of underground line below.

Use Vinyl or Vinyl Cloth Wire/Cable Designation Tape Markers that are self adhesive wrap-around cable/conductor markers with pre-printed numbers and letters for designation purposes.

Cut Aluminum Wrap-Around Cable Marker Bands from 0.014-inch thick aluminum sheet and fitted with slots or ears for securing permanently around wire or cable jacket or around groups of conductors. Provide for legend application with stamped letters or numbers.

Engraved Plastic-Laminate Labels, Sign and Instruction Plates shall be engraving stock melamine plastic laminate, 1/16-inch minimum thickness for up to 20 square inch sign or 8-inch length; 1/8 inch thickness for larger sizes. Engrave legend in white letters on black face and punch for mechanical fasteners.

Use Baked Enamel Warning and Caution Signs that are pre-printed aluminum signs appropriate to the location, punched for fasteners, and sized for good visibility.

Use Fasteners for Plastic Laminate and Metal Signs that are self tapping stainless steel screws or No. 10/32 minimum stainless steel machine screws with nuts and flat and lock washers.

Use Cable Ties that are fungus-inert, self-extinguishing, one piece, self locking nylon cable ties, 0.18 inch minimum width, 50 pounds minimum tensile strength and suitable for a temperature range from -50°F to +350°F. Provide ties in specified colors when used for color coding.

d. Installation.

Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations, specified or indicated in the Contract Documents. Provide numbers, lettering and wording as approved in submittals, as required by code, or as recommended by manufacturers.

Install products covered by this Section where indicated on drawings or specified. Install products covered by this Section where required by NFPA 70, whether or not otherwise indicated. Install products in accordance with manufacturer's written instructions and requirements of NFPA 70.

Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

In all areas where inside circuits are routed from a vault through an inhabited space, identify all exposed high voltage feeder conduits (over 600 volts) by words "DANGER-HIGH VOLTAGE" in black letters 2 inches high, stenciled on adhesive labels at 10-foot intervals over continuous painted orange background applied as follows:

- (1) On entire floor area directly above conduits running beneath and within 12 inches of basement or ground floor in contact with earth or framed above unexcavated space.
- (2) On wall surfaces directly exterior to conduits run concealed within the wall.
- (3) On all accessible surfaces of concrete envelope around conduits in vertical shafts exposed at ceilings or concealed above suspended ceilings.
- (4) On entire surface of exposed conduits.
- (5) Clean surface of dust, loose material and oil films before painting.

- (6) Prime unpainted surfaces. For galvanized metal use single component acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units use heavy duty acrylic resin block-filler. For concrete surfaces use clear alkali-resistant alkyd binder type sealer.
- (7) Provide one intermediate and one finish coat of orange silicone alkyd enamel.
- (8) Apply all primer and finish materials in accordance with manufacturer's instructions.

Identify Pull and Connection Boxes with pressure sensitive, self-adhesive labels indicating system voltage in black pre-printed on orange background as required by NFPA 70 for caution signs on all electrical power and lighting system boxes. Install on the outside of the box cover. Also label box covers to identify the circuits. Use pressure sensitive plastic labels at exposed locations and similar labels or plasticized card stock tags at concealed boxes.

During backfilling of the trench for each exterior underground communications and control circuit, install continuous underground-type plastic line marker, located directly above line at 6 to 8 inches below finished grade. Where multiple lines are installed in a common trench or concrete envelope and do not exceed and overall width of 16 inches, install a single line marker.

Provide identifying metal tags or aluminum wrap-around marker bands securely fastened to all power circuit cables, feeders, and power circuits in electrical equipment rooms, pull boxes, junction boxes, manholes and hand holes with tags or bands with 1/4-inch steel letter and number stamps with legend to correspond with designations on drawings. If metal tags are provided, attach them with approximately 55-pound test monofilament line or one piece self-locking nylon cable ties.

Tag or label conductors as follows:

- (1) Tag or label all conductors with identification indicating source and circuit numbers.
- (2) Where Multiple branch circuits or control wiring or communications/signal conductors are present in the same box or enclosure, label each conductor or cable. Provide legend indicating source, voltage, circuit number as applicable. For control and communications/signal wiring, use wire/cable marking tape at terminations and at all intermediate locations where conductors appear in wiring boxes, troughs and control cabinets. Use consistent letter/ number conductor designations throughout on wire/cable marking tapes.
- (3) Match identification markings with designations used in panelboards, shop drawings, contract documents and similar previously established identification schemes for the facility electrical work.
- (4) Where required by NFPA 70, to ensure a safe operation and maintenance of electrical systems and of the items to which they connect, install warning, caution or instruction signs. Where instructions or explanations are needed for system or equipment operation, provide engraved plastic laminated instruction signs with approved legend. For outdoor items provide butyrate signs with metal backing.
- (5) For emergency instructions or other emergency operations, provide engraved laminated signs with approved white legend on red background with minimum 3/8-inch high lettering.

Provide sign or stenciled legend to identify equipment concealed behind bolted covers of housing for disconnecting switches, transformers and switchboards.

Stencil or provide an equipment identification label of engraved plastic-laminate of each major unit of electrical equipment; including central or master unit of each electrical system. This includes communication /signal systems, unless a unit is specified with its own self-explanatory identification. Except as otherwise indicated, provide a single line of text, and a minimum 1 inch high lettering. Engraved labels shall be 2 inches high black lettering in white field. Provide text that matches terminology and numbering of the contract document and shop drawings. Provide label for each unit of the following categories of electrical work:

- (1) Panelboards, electrical cabinets and enclosures.
- (2) Access doors and panels for concealed electrical items.
- (3) Electrical switchgear and switch boards.
- (4) Regulators.

- (5) Power transfer equipment.
- (6) Contactors.
- (7) Remote controlled switches.
- (8) Control devices.
- (9) Transformers.
- (10) Power generating units.

For panelboards, provide circuit schedules with explicit description and identification of items controlled by each individual breaker.

Stencil and install labels at locations for best convenience of viewing without interference with operation and maintenance of equipment.

100–3.10 SECONDARY GROUNDING. Provide secondary grounding as indicated on the Drawings and in accordance with the following Specifications.

a. Section Includes.

- (1) Materials and methods for grounding constant voltage 600V or less electrical systems only.
- (2) Grounding conductors.
- (3) Bonding jumpers.
- (4) Ground bus.
- (5) Ground rods.
- (6) Grounding terminations.

b. References.

- (1) American National Standards Institute (ANSI). Comply with the requirements of ANSI C2 National Electric Safety Code.
- (2) American Society for Testing and Materials (ASTM). Comply with the requirements of ASTM B1 Standard Specification for Hard–Drawn Copper Wire.

c. Products.

Provide insulated equipment grounding conductors that run in the same raceway with circuit wires.

Provide bare ground conductors for grounding of transformers, switch gear, other service equipment, grounding service poles and electrical equipment structures both underground and above ground. Conductors shall be stranded copper conductors.

Provide braided copper tape constructed of No. 30 gauge bare copper wires sized to suit the application.

Ground rods are as indicated by the Contract Documents and NFPA 70. All rods shall have a hard, clean, smooth continuous surface throughout the entire length of the rod.

Where welded connections are required, such welds shall be made by the exothermic process utilizing factory provided molds.

d. Installation.

Deliver grounding materials in factory–sealed containers and with conductors wound on National Electrical Manufacturers Association (NEMA) wire and cable reels.

Store grounding materials in a clean dry space in original containers. Protect products from weather, damaging fumes, construction debris, and traffic.

Supplement the grounded neutral of the secondary distribution system with an equipment grounding system to properly safeguard equipment and personnel. The system shall, as a minimum, comply with NFPA 70.

Provide the equipment grounding system so that all metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, frames, portable equipment, and other conductive items in close proximity with electrical circuits operate continuously at ground potential and provide a low impedance path for possible ground fault currents.

In bus installations other than UL listed assemblies, provide where indicated, a bare copper ground bus spaced 1 inch from the wall and not more than 6 inches above the finished floor in each electrical equipment area. The required length of the ground bus shall be as shown in the Contract Documents. Connect the ground bus by utilizing hard-drawn copper conductors and make connections between the conductors and the ground bus with connectors UL listed for the application.

Drive electrical system ground rods until the top is 6 inches below the final grade.

Interconnect the electrical system ground rods with bare copper grounding electrode conductors buried at least 24 inches below grade.

Size all required equipment grounding and grounding electrode conductors and straps in compliance with NFPA 70. Provide insulated equipment grounding and grounding electrode conductors of the same type and class for the associated phase and neutral conductors of the secondary distribution system.

Provide the proper number and size of pressure connectors required for all equipment grounding bars in panel boards and other electrical equipment for the termination of equipment grounding conductors. Provide pressure connectors for all active and spare circuits.

Where metallic conduits terminate at a metallic housing without mechanical connection, such as locknuts and bushings, provide each conduit with a ground bushing. Connect each ground bushing with a bare copper bonding jumper to the ground lug or bus in the electrical equipment. Size the conductor as required by NFPA 70.

Make all ground connections with UL listed products.

Where an insulated ground wire is connected to ground rods below grade or in wet locations, insulate the connection and seal against moisture penetrating under the insulation.

100–3.11 PANELBOARDS. Provide panel boards as indicated on the drawings and in accordance with the following Specifications.

a. Section Includes.

- (1) Distribution panel boards.
- (2) Lighting and appliance branch circuit panel boards.

b. Section Does Not Include.

- (1) Switchboards.
- (2) Service entrance equipment.

c. References.

- (1) National Electrical Manufacturers Association (NEMA). Provide panel boards and switches constructed and configured in accordance with the following:

NEMA	AB 1 Molded Case Circuit Breakers and Molded Case Switches
NEMA	KS 1 Enclosed Switches
NEMA	PB 1 Panel boards

- (2) National Fire Protection Association (NFPA). Conform to the requirements of NFPA 70.
- (3) Underwriters Laboratories, Inc. (UL): Construct panel boards in accordance with the following UL publications:

UL	50	Cabinets and Boxes
UL	67	Panel boards
UL	310	Electrical Quick–Correct Terminals
UL	486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors
UL	489	Molded–Case Circuit Breakers and Circuit–Breaker Enclosures
UL	943	Ground–Fault Circuit Interrupters
UL	1053	Ground–Fault Sensing and Relaying Equipment

d. Products.

- (1) Distribution Panel boards.

Provide panel boards with buses constructed of solid copper, minimum conductivity 98 percent and rectangular shape.

- (a) Mechanically mount and brace buses in conformance with UL 67.
- (b) Provide solderless lugs for copper cable.
- (c) Provide ampacity as indicated on the drawings.

Provide bare, uninsulated copper, factory installed grounding bus with ampacity equal to the main bus. Provide copper pressure connected terminations.

Provide bus bar connections to branch circuits of the sequenced phased type.

- (a) Mount in accordance with UL 67.
- (b) Provide numbered terminals.
- (c) Provide pressure connectors for copper.

Where words similar to "space", "space only", "future space", or similar wording are used on the drawings and panel schedules, provide bus space for future overcurrent devices.

- (a) Extend buses full size.
- (b) Brace and insulate bus in accordance with UL 67.
- (c) Provide bolted connections for future overcurrent devices.

Construct enclosures in accordance with UL 50 except modify as hereinafter specified.

- (a) Construct of minimum 16–gauge galvanized steel NEMA 1, unless indicated otherwise in the Contract Documents.
- (b) Conform to UL 67 for additional enclosure requirements.
- (c) Provide inner and outer door with hinged trim.
- (d) Panel board, back–box and front plate produced from one manufacturer. Factory fit components before shipment.
- (e) Provide enclosure type in conformance with UL 50 and NEMA PB 1.

(f) Provide removable front plates of the dead-front type with removable, and flush hinged enclosure door.

(g) Provide a keyed lock for circuit breaker access cover.

Provide multiple knockouts not fewer than 1.5 times the number of bus circuits.

In addition to the priming coat, all inside and outside surfaces of trim and doors shall be given a factory finish coat of gray paint. Paint recessed boxes, and surface boxes in vaults, switchgear rooms and electrical equipment enclosures as previously described.

Provide factory printed directories with a clear plastic directory cover and metal frame attached to the panel door.

Provide Wiring Space that conforms to the requirements of UL 67. Feed-through gutters are not permitted.

(a) Conform to NFPA 70 for maximum gutter fill.

(b) Conform to UL 67 for minimum width of gutter and wire bending space.

Breakers shall have inverse time automatic tripping.

Provide adjustable trip circuit breakers as noted in the Contract Documents.

Use factory assembled bolt-in type circuit breakers, except breakers 225 amperes frame size and larger may be plug-in type if held in place by positive locking device requiring mechanical release for removal.

Integrally fused circuit breakers with inverse time automatic tripping, and fuses shall conform to UL 198B, 198C, 198D, 198E, 198F, 198G, 198H, 198L, and 198M.

Provide breakers as indicated in the Contract Documents with current interrupting ratings, in RMS symmetrical amps.

(2) Lighting and appliance Branch Circuit Panel boards.

Provide enclosures, bus systems, spacing and knockouts same as for distribution panel boards.

Provide interrupting ratings, circuit arrangements, and trip settings as noted in the Contract Documents.

Provide common trip mechanisms for multi-pole breakers.

Provide instantaneous automatic trips conforming to NEMA AB 1.

Breakers shall be bolt-on type, factory assembled.

Stab-in circuit breaker types are not acceptable.

Provide quick-make and quick-break mechanism.

e. Installation.

Install panel boards in conformance with NEMA PB 1 and NFPA 70.

Torque lug screws in accordance with UL 486A for copper conductors and UL 486B for aluminum conductors. Install connectors, lugs, neutral bus and other field installed components in accordance with manufacturer's published literature.

Verify gutter size conforms to wire bending space requirements of NFPA 70 and UL 67.

Wire wrap branch circuits in gutters after installation. Use approved wire ties.

Verify maximum gutter fill to conform with NFPA 70 and UL 67.

Verify bolted circuit breaker connection lugs conforming to shop drawings.

Verify breaker size, trip setting, and breaker type in conformance with Contract Documents.

Complete typewritten panel board circuit directory prior to project acceptance.

Only wires made of the conductor material for which the panel board terminals have been marked shall be used.

Adjustable Trip Settings. Install lugs and ground connectors in conformance with UL 486A and UL 486B. Verify factory settings for adjustable trip breakers. Field adjust in conformance with manufacturer's recommendations, if necessary.

100–3.12 OVERCURRENT PROTECTIVE DEVICES. Provide overcurrent protective devices as indicated on the drawings and according to these specifications.

a. Section Includes.

- (1) Molded case circuit breakers.
- (2) Heavy duty safety switches.
- (3) Combination molded case circuit breakers and current-limiting fuses.

b. Section Does Not Include.

- (1) Main service switches.

c. References.

- (1) National Electrical Manufacturers Association (NEMA). Provide and install fuses and circuit breakers conforming to NEMA, including:

NEMA	AB–1	Molded Case Circuit Breakers and Molded Case Switches.
NEMA	AB–2	Field Inspection and Performance Verification of Molded Case Circuit Breakers Used in Commercial and Industrial Applications, Procedures for.
NEMA	AB–3	Molded Case Circuit Breakers and Their Application.
NEMA	FU–1	Low Voltage Cartridge Fuses.

- (2) National Fire Protection Association (NFPA). Comply with NFPA 70, "National Electrical Code" requirements as applicable to construction and installation of overcurrent devices.

- (3) Underwriters Laboratories, Inc. (UL): Provide overcurrent protective devices that are UL-listed and labeled. Provide fuses and circuit breakers conforming to UL including:

UL	512	Fuseholders
UL	198B	Class H Fuses
UL	198C	High-Interrupting-Capacity Fuses, Current-Limiting Types
UL	198D	Class K Fuses
UL	198E	Class R Fuses
UL	198G	Fuses for Supplementary Overcurrent Protection
UL	198H	Class T Fuses
UL	489	Molded-Case Circuit Breakers and Circuit-Breaker Enclosures.

d. Products.

- (1) Enclosures shall be NEMA 1, unless otherwise indicated in the Contract Documents. Enclosures shall have an externally operable handle with interlock to prevent opening of front cover with the switch in the "ON" position. Handle shall be lockable in the "OFF" position.

- (2) Molded Case Circuit Breakers.

Circuit breakers shall conform to NEMA AB 1.

Use circuit breakers that have a trip rating and number of poles as indicated on the Contract Documents.

Use circuit breakers that have an interrupting current rating equal to or greater than the available fault current at their location in the electrical system, unless otherwise specified. Provide a minimum rating of 10,000 amperes symmetrical, unless a greater rating is shown on the Contract Documents.

Use circuit breakers from the same manufacturer.

Provide circuit breakers with a quick-made and quick-break toggle mechanism with inverse-time trip characteristics.

Automatic release is to be secured by a bimetallic thermal element releasing the mechanism latch.

A magnetic armature shall be provided to trip the breaker instantaneously for short-circuit currents above the overload range.

Automatic tripping shall be indicated by a handle position between the manual OFF and ON position.

Provide adjustable magnetic trip devices adjusted at the factory to "low" trip setting ampere values.

(3) Heavy Duty Safety Switches.

Provide quick make, quick break load interrupter enclosed knife switch assemblies.

Provide fuses that conform to UL 198B, 198C, 198D, 198E 198F, 198G, 198H, 198L, and 198M. Provide fuses of the sizes noted on the Contract Documents.

Install current-limiting fuses instead of regular fuses where the fault current exceeds 10,000 RMS amperes.

Fuses rated over 600 amperes shall be NEMA Class L.

Fuses for use with switches rated 600 amperes and less shall be UL Class RK-5 or RK-1 as noted, unless otherwise specified. Class RK-5 and RK-1 fuses shall be dual element type with minimum time-delay of 10 seconds at 500 percent of rating.

Provide one complete set of fuses installed for all switches requiring fuses. Provide one spare fuse of each size and type installed.

(4) Combination Molded Case Circuit Breaker and Current-Limiting Fuses.

Where the short circuit current exceeds the interrupting ratings of molded case circuit breakers, provide high-interrupting capacity integral current limiters on the load side of the circuit breakers.

The circuit breaker and limiter combination shall be a coordinated unit meeting the applicable requirements of UL 489, so designed that the normal thermal magnetic overcurrent devices provide coordinated protection against overloads and short circuits up to a predetermined value. The current limiters shall assume the fault-clearing duty and extend short circuit protection up to and including 100,000 RMS amperes.

High-interrupting-capacity circuit breakers adequate for the short circuit current available at the particular location in the system may be provided instead of the combination current limiting fuse units.

d. Installation.

Install overcurrent protective devices as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that protective devices comply with requirements. Comply with NFPA 70 and NEMA standards for installation of overcurrent protective devices.

Coordinate with other work, including electrical wiring work, as necessary to interface installation of overcurrent protective devices with other work.

Fasten overcurrent devices without causing mechanical stresses, twisting or misalignment being exerted by clamps, supports, or cabling.

Set field-adjustable circuit breakers for trip settings as indicated, subsequent to installation of units.

Install fuses and package the spare fuses in an orderly fashion.

Inspect circuit-breaker operating mechanisms for malfunctioning and, where necessary, adjust units for free mechanical movement.

Prior to energization of overcurrent protective devices, test devices for continuity of circuitry and short-circuits. Correct malfunctioning units, and then demonstrate compliance with requirements.